Soil Organic Carbon in Livestock and Cropping Systems in the Southeastern USA

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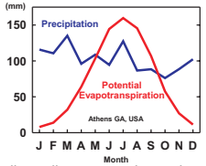
Land use in the Southern Piedmont

59% forest
13% urban/road
12% pasture
9% cropland
3% water
5% other

Environmental characteristics at Watkinsville GA in the Southern Piedmont region of the southeastern USA



16.5 C annual temperature
125 cm annual precipitation
156 cm annual pan evaporation
225 frost-free growing days

Dominant soils: clayey, kaolinitic, thermic Typic Kanhapludults

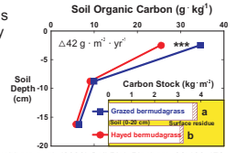
Relatively long, warm-moist climate allows diverse cropping and forage management systems with poultry manure available

Cropping
Typically cotton, peanut, corn, soybean, wheat, and a diversity of other crops with either cover or double cropping potential

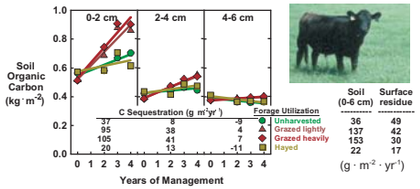
Forage
Warm-season perennials (bermudagrass, bahiagrass) either grazed or hayed along with cool-season perennial (tall fescue) and a diversity of annuals (ryegrass, rye, various clovers)

1. Cattle grazing versus haying of forage

Appropriate grazing systems with moderate cattle density and adequate fertility can sequester soil organic C at a rate higher than with haying. Return of feces to soil rather than removal of forage is important.



Franzluebbers et al. (2000) Soil Biol. Biochem. 32:469-478

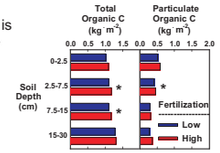


Franzluebbers et al. (2001) Soil Sci. Soc. Am. J. 65:834-841

2. Fertilization of forage

Appropriate basal fertilization is necessary to obtain adequate forage growth.

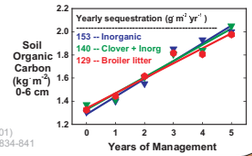
Carbon cost of nitrogen fertilizer (0.5 g C g^{-1} N) is 10 g m^{-2} to supply 20 g N m^{-2}, which is lower than soil C sequestration during early years, but may equal or exceed soil C sequestration during later years.



Low (13.4-1.5-5.6) and high (33.6-3.7-13.9) fertilization (g N-P-K · m^{-2} · yr^{-1}) of tall fescue for 15 years. Gain in total organic C with high vs low fertilization was 260 g · m^{-2}.

Schnabel et al. (2001) Pot. U.S. Grazing Lands to Sequester C, Lewis Publ., Boca Raton, FL

Whether nutrients were derived from organic or inorganic sources, soil organic C sequestration was equally high. Carbon cost of fertilization was low (7-9%) relative to soil organic C gain.



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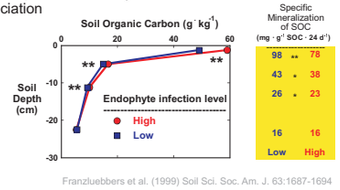
3. Endophyte infection of tall fescue

Endophyte infection of tall fescue has been shown to enhance soil organic C accumulation.
Possible reasons are:
1 greater productivity potential of endophyte-infected grass resulting in more C fixed and subsequently stored in soil
2 inhibition of soil microbial biomass and activity by various alkaloids and other compounds produced through the association

Addition of 'Kentucky-31' tall fescue leaf tissue [either with (+) or without (–) the presence of endophyte] resulted in the following increases in soil C pools:

	–	Pr>F	+
Soil microbial biomass C (mg · kg-1 soil)	293	0.12	196
Potential C mineralization (mg · kg-1 soil · 32 d-1)	1256	0.06	1227

Unpublished data



Franzluebbers et al. (1999) Soil Sci. Soc. Am. J. 63:1687-1694

4. Spatial distribution of soil C in pastures

Soil organic C in pastures varies predictably with depth and distance from shade/water sources.

Significant differences in organic C are typically found in the surface 30 cm and not below, because of increasing natural variability and low organic C concentration.

Cattle spend more time near shade/water sources, resulting in greater deposition of feces and avoidance of spoiled forage.

Least significant difference ($LSD_{p=0.1}$, g · m^{-2} · yr^{-1}) and coefficient of variation (CV, %) in soil organic C between means from 1994 and 1999.

Incremental Depth (cm)	LSD	CV	Cumulative Depth (cm)	LSD	CV
0 – 15	89	42	0 – 15	89	42
15 – 30	30	259	0 – 30	92	46
30 – 60	66	110	0 – 60	141	101
60 – 90	86	162	0 – 90	152	176
90 – 120	49	189	0 – 120	178	295
120 – 150	19	62	0 – 150	192	674

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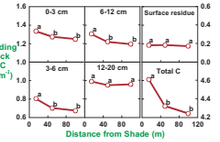

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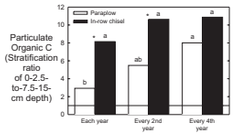
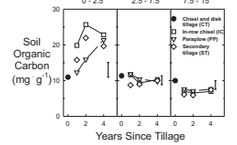
5. Tillage type and frequency

Disturbance of soil with inversion tillage causes loss of soil organic C, especially near the soil surface. Non-inversion tillage types can be used without reducing soil organic C greatly.

If the frequency of tillage could be limited, maintenance of higher soil organic C could be achieved even in soils of the southeastern USA where decomposition is rapid.



Franzluebbers (2002) Soil Till. Res. 66:95-106

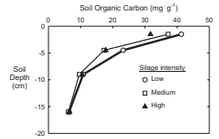


Franzluebbers et al. (1999) Soil Sci. Soc. Am. J. 63:349-355

6. Silage cropping intensity

Management of soil with continuous no tillage, but without return of crop residues to the soil surface could lead to compaction and little accumulation of soil organic C.

Alternative cropping systems with less intensive silage harvest and more crop residues returned to the soil can lead to accumulation of soil organic C near the soil surface.



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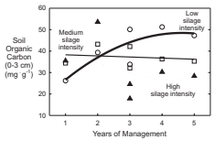

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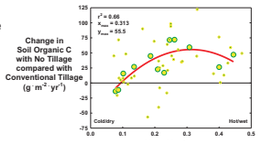
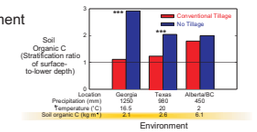
7. Climatic limits to sequestration of soil organic C with no tillage

Available literature suggests that moderate climatic zone in the USA may have the highest potential to store soil organic C with conversion from inversion tillage systems to no tillage.

Cold/dry climates have higher inherent stock of soil C, but conservation management systems are not as stimulating for the accumulation of soil organic C as they are in hot/wet climates.



Franzluebbers and Steiner (2002) Agric. Pract. Policies for C Sequestr. Soil, Lewis Publ., Boca Raton, FL



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8. New investigations

Soil organic C sequestration is a practical means to mitigate rising atmospheric CO_2 concentration, as well as improve agricultural productivity and food security. Satellite imagery, field sampling, and crop/soil modeling will be used to assess C stock changes attributable to community-based agriculture and natural resource management decisions.

Soil organic C dynamics under integrated crop/livestock systems with and without tillage are being investigated. The effects of animal traffic or not during cool-wet and hot-dry seasons and of cropping following long-term pasture are key issues.